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EFFECTS OF STRUCTURE AND SEQUENCE ON ADULT LEARNING. PAPER PRESENTED AT THE NATIONAL SEMINAR ON ADULT EDUCATION RESEARCH (CHICAGO, FEBRUARY 11-13, 1968).

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IN THIS STUDY ON THE EFFECTS OF STRUCTURE AND SEQUENCE ON ADULT LEARNING, 96 ADULTS UNFAMILIAR WITH NUMBER BASES AND RANGING IN AGE FROM 23 TO 53 WERE RANDOMLY ASSIGNED TO FOUR DIFFERENTIALLY STRUCTURED INTRODUCTORY MATERIALS (HISTORY OF MEASUREMENT, BASE TEN, BASE SEVEN, OR PRINCIPLES OF NUMBER BASES) AND TO THREE DIFFERENTIALLY SEQUENCED LEARNING TASK CONDITIONS (RANDOM, PARTIAL, OR COMPLETE) WITHIN FOUR INTELLIGENCE AND TWO SEX CATEGORIES. SUBJECTS WERE INDIVIDUALLY PRESENTED THE BASE FOUR TASK IN PAIRED ASSOCIATE FORM AFTER THEY HAD RECEIVED THE PROGRAMED INTRODUCTORY MATERIAL. THE INTRODUCTORY MATERIAL APPEARED TO HAVE SIGNIFICANTLY POSITIVE RESULTS ONLY WITH SUBJECTS HAVING SUPERIOR INTELLIGENCE. THE COMPLETELY SEQUENCED LEARNING TASK RESULTED IN A MORE RAPID MASTERY OF THE LEARNING TASK, ESPECIALLY WITH LESS INTELLIGENT SUBJECTS. RELIABLE DIFFERENCES AMONG THE INTELLIGENCE CATEGORIES AND BETWEEN THE SEXES WERE ALSO OBSERVED. (ALSO INCLUDED ARE CHARTS, TABLES, AND 17 REFERENCES.) THIS PAPER WAS PRESENTED AT THE NATIONAL SEMINAR ON ADULT EDUCATION RESEARCH, CHICAGO, FEBRUARY 11-13, 1968. (AUTHOR/LY)

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ABSTRACT

EFFECTS OF STRUCTURE AND SEQUENCE ON ADULT LEARNING

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Ss were 96 adults unfamiliar with number bases and ranging in age from 23 to 53. They were randomly assigned to four differentially structured introductory material (history of measurement, base ten, base seven, or principles of number bases) and three differentially sequenced learning task (random, partial, or complete) conditions within four intelligence and two sex categories. *Ss* were individually presented the base four task in paired associate form after they had received the programed introductory material. The effect of the introductory material appeared to be greater for *Ss* with superior intelligence. The completely sequenced learning task resulted in a more rapid acquisition of the learning task, especially with the less intelligent. Reliable differences among the intelligence categories and between sexes were also observed.

Paper presented at 1968 National Seminar in Adult Education Research

EFFECTS OF STRUCTURE AND SEQUENCE ON ADULT LEARNING[1]

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Studies by Ausubel and his associates (Ausubel, 1960; Ausubel & Fitzgerald, 1961, 1962; Ausubel & Youssef, 1963; Fitzgerald & Ausubel, 1963) have investigated the effects of introductory materials on the learning and retention of potentially meaningful verbal material. The results have indicated that the learning and retention of meaningful verbal material can be facilitated through the use of introductory materials.

Ausubel (1963, 1965) has theorized that meaningful learning is facilitated by two variables which enhance the learner's cognitive structure (i.e., his existing organized body of knowledge regarding a learning topic). The first variable is the *structure* of the subject matter itself. The second variable is the *sequencing* of the subject matter.[2]

The purpose of the present study was to experimentally manipulate these two aspects of the instructional process. More specifically, this study was aimed at determining the effects of differentially structured introductory materials on conceptually related learning tasks which were differentially sequenced. The effects of the learner's intelligence and sex on learning were also to be determined.

METHOD

Subjects

The *S*s were selected from a sample of adults who had participated in a previous research project (Sjogren & Knox, 1965) at the University of

Nebraska. The selected sample consisted of 96 adults, 48 men and 48 women, ranging in age from 23 to 53, and in intelligence from 102 to 161. The intelligence scores were the full scaled scores obtained from the *Wechsler Adult Intelligence Scale* (WAIS). The *S*s were unfamiliar with the number base learning topic (had scores of six or less on a 15 item multiple choice test), and on the average had completed two years of college. Table 1 presents the means and standard deviations of the sam-

Insert Table 1 about here

ple characteristics by sex and intelligence level. All *S*s were volunteers. They were each paid $5.00 for their participation in the study.

Experimental Design

The experimental design was a fixed effects 4 X 3 X 4 X 2 factorial. The *S*s were randomly assigned to four levels of introductory materials and three levels of learning tasks within four levels of intelligence and two levels of sex.

Introductory Materials

Four differentially structured introductory materials were used. The introductory materials were linear programs presented in booklet form. They included the topics of (a) history of measurement,[3] (b) base ten number system, (c) base seven number system, and (d) principles of number bases. The history material was intended primarily as a control treatment. It contained historical and descriptive information on several units of measurement, such as cubit, span, digit, and hand.

Each of the three experimental treatment programs was written with its sequential steps parallel to the steps of the other experimental treatment programs. The base ten material presented concepts of grouping, numbers, numerals, face value, and place value. The introductory materials on both base seven and principles covered concepts similar to those presented in the base ten introductory material.

The experimental treatment programs were presumably structured to provide information which was relatable in varying degrees to the number base learning topic. The introductory material on base ten was presumably structured so that it was less general but more familiar to the learner than the introductory material for base seven and principles. It was reasoned that if the base ten material presented principles in a specific context familiar to the learner, then the material would be less relatable to the number base topic. The base seven material was presumably structured to be more general and less familiar than the base ten material, because it presented principles in a specific context which was unfamiliar to the learner, but related to the learner's existing relevant knowledge. The principles program was structured to present principles which could be applied to a number of contexts. Thus, it was expected to be more relatable to the number base topic than the base ten and seven treatments.

Table 2 presents summary information about the introductory programs and the *S*s' responses for each of the programs. The mean number of errors for the experimental treatments provides evidence to support the assumption regarding the familiarity of the experimental treatments. Furthermore,

the data indicated that error rate was positively related ($r = .52$) to time taken to complete the introductory material, completion time of the introductory material was negatively related ($r = -.40$) to intelligence level (WAIS full scaled scores), and intelligence level was negatively related ($r = -.41$) to error rate.

Insert Table 2 about here

Evidence that individuals learned by studying the programed materials was obtained from pilot sessions with adults. The results indicated that a significant gain in knowledge occurred between a pretest and a posttest.

Learning Tasks

The learning task treatment consisted of three differentially sequenced sets of paired associates which corresponded to numbers in the base four number system. The number word was used as the stimulus and the required response was an unfamiliar symbol (ק , ך , ך , or ך) or combination of these symbols. These four basic symbols represented the number values of zero through three, respectively, or the basic symbols necessary for writing number values in base four.

In one of the learning tasks, the stimulus words were presented according to numerical value. In the second learning task, the first five stimulus words were presented in numerical order, and the remaining stimulus words were presented in random order. In the third learning task the stimulus words were presented randomly. There was a total of 13 paired associates

in each trial of the three learning task treatments. Each trial's paired associates were always presented in the same prescribed order.

Criterion Measures

Several criteria were used to measure the effectiveness of theexperimental treatments on learning. The three measures were (a) number of correct responses on an immediate posttest on base four, (b) numberof trials to a criterion of two perfect repetitions, and (c) number oftotal errors made to criterion. The 14 item completion posttest had two arts. One part measured learning, and the other measured transfer.

Procedures

All *S*s attended an individually arranged session at which they were administered a randomly selected set of introductory materials. The *S*s made written responses in the programed booklets as they studied them. After completing the introductory material, *S*s were administered a prelearning task by a randomly assigned *E* (*E*s were 10 young adults stratified according to sex). The purpose of the prelearning task was to have the *S*s learn the four basic symbols to be used in the subsequent learning task. Immediately after learning the four basic symbols to a specified criterion, *E*s presented the *S*s the randomly assigned learning task in a modified TMI-Grolier Min-Max Teaching Machine.

The *S*s were presented with a stimulus word (e.g., ZERO) in the aperture of the apparatus, and were expected to write the appropriate symbol (e.g., ϙ) on the response tape in the attached answer-mate. After a nine second interval the stimulus number word appeared together with the correct response symbol in the aperture. After receiving feedback

regarding the correctness of this response to the stimulus word for six seconds, the stimulus word and the correct symbol along with the *Ss'* response disappeared from sight as the next stimulus word was presented.

Upon responding correctly to two trials of the paired associates task the *Ss* were administered the posttest. The *Ss* were required to respond on the test with the symbols represented by the given number words. Five of the number words were from the paired associates contained in the learning task, and nine were transfer items which could be answered correctly if the *Ss* could generalize to base four symbols not learned in the task. In addition to the posttest score, measures of trials and errors to criterion were obtained.

RESULTS

Table 3 presents the results of the analysis of variance performed on each of the criteria. The error terms for each analysis were obtained by aggregating the four- and three-way interactions. This procedure was consistent with the hypotheses of the study and the suggestion by Green and Tukey (1960). There were no statistically significant differences among the introductory material treatments for each of the three criteria. Statistically significant differences ($p < .01$) were observed among the learning task treatments for the trials and errors measures, but not for

Insert Table 3 about here

the posttest measure. The similarity between the analyses of the trials and errors measures was expected because these two criteria correlated .97 with each other.

A comparison of the trials means by Tukey's test (Glass, 1967) revealed that the completely sequenced treatment differed significantly from the randomly (q (3,57) = 7.71, $p < .01$) and partially (q (3,57) = 8.58, $p < .01$) sequenced tasks. Likewise, the completely sequenced task differed significantly from the errors means of both the partially (q (3,57) = 6.76, $p < .01$) and randomly (q (3,57) = 7.24, $p < .01$) sequenced tasks. The negligible difference between the partial and random treatments probably occurred because four of the first five symbols in each trial under the partial treatment had been prelearned. Consequently, the *Ss* who were administered the partial treatment were not able to benefit fully from the sequential ordering of the first five symbols because the first four symbols were already familiar to them. This also explains why a slight difference in the order of the learning task means was observed between the trials and errors measures.

A significant difference ($p < .01$) was observed among the intelligence quartiles for each of the criteria. As expected, the means of the intelligence quartiles were ordered from high to low. A comparison of the posttest means by the Tukey method indicated a significant difference between the first and fourth quartiles (q (4,57) = 6.24, $p < .01$). On the trials means the first quartile differed significantly from the second (q (4,57) = 4.13, $p < .05$), third (q (4,57) = 4.55, $p < .05$), and fourth (q (4,57) = 8.90, $p < .01$) quartiles. The fourth quartile differed significantly from the second (q (4,57) = 4.76, $p < .01$) and third (q (4,57) = 4.35, $p < .05$) quartiles. Finally, Tukey's test showed that the errors mean of the fourth quartile differed significantly from the first (q (4,57) = 8.11, $p < .01$),

second (q (4,57) = 4.79, $p < .01$), and third (q (4,57) = 4.57, $p < .05$) quartiles.

An analysis of the posttest data indicated a significant ($p < .01$) sex main effect and an intelligence by sex disordinal interaction. Men scored relatively higher than women at all levels of intelligence with the exception of the lowest quartile.

To further test the conclusion by Ausubel and Fitzgerald (1962) that introductory materials were more beneficial for learners of low verbal ability, an analysis of variance was conducted on the criteria of the first and fourth intelligence quartiles. The findings were similar to those presented previously, with two exceptions. The analysis of the trials data indicated that the introductory material by intelligence interaction approached significance (F (3,23) = 2.37, $p < .10$). The graphic presentation

Insert Figure 1 about here

of this ordinal interaction is presented in Figure 1. The high intelligence quartile appeared to benefit more from the introductory material than did the low intelligence quartile. The order of the means for the upper quartile was the same as the predicted ordering. Second, a noticeable ordinal learning task by intelligence interaction was observed (F (2,23) = 2.90, $p < .10$). This interaction is presented in Figure 2. The low intelligence quartile appeared

Insert Figure 2 about here

to profit more from the completely sequenced task than did the high quartile. As expected, similar interaction effects were noted with the errors data.

DISCUSSION

The findings did not support the expectation that differentially structured introductory materials would facilitate learning a conceptually related learning task. There was, however, evidence to indicate that the introductory materials were facilitative for *S*s of superior intelligence. This finding is consistent with those obtained by Grotelueschen and Sjogren (1968) who found that introductory materials facilitated the learning and transfer of new material for adult *S*s of superior intelligence. These findings and those of the present study suggest that the complexity of the learning topic is a variable to consider in ascertaining the extent to which introductory materials facilitate learning.

The evidence of the present study indicated that *S*s of low intelligence had more difficulty in studying the introductory material because it was either too difficult or the learning topic was too abstract. The relatively low error ratio obtained for the programs (cf. the mean number of errors to the number of responses required for each programed treatment in Table 2) seems to support the explanation that the topic was too abstract.

Theoretically it is assumed by Ausubel (1963) that the reception of abstract information in the form of introductory learning material is limited for young learners who have immature cognitive structures. The findings of the present investigation suggest that the reception of abstract material also has a limited effect for adult learners who have little background knowledge regarding the learning topic and who are less

intelligent. Recent evidence by Scandura and Wells (1967) suggests the use of introductory material presented at a more concrete level. For instance, they found that concrete model organizers (mathematical games) facilitated the learning of abstract mathematical materials. The extent to which abstract or concrete introductory materials are facilitating is dependent upon such factors as the level and difficulty of the learning material as well as the intelligence and relevant subject matter knowledge of the *S*s.

A limiting factor of the present study was the lack of variance associated with the posttest measure. A ceiling effect was observed on the learning task item subscore, and a floor effect was observed on the transfer subscore.

The trials and errors data suggested that a completely sequenced learning task resulted in more rapid acquisition of the material than did a partially or randomly sequenced task. Furthermore, the evidence suggested that the effect of the completely sequenced learning task appeared to be especially beneficial for adults with relatively low intellectual abilities. This finding is of particular importance when contrasted with the introductory material by intelligence finding.

No evidence was found to suggest that the effects of differentially structured introductory materials would be less facilitative for a completely sequenced learning task than a learning task presented in a random manner. Future research might be conducted to test the hypothesis that the relative effect of a completely sequenced learning task would become greater as the introductory material became less structured.

As anticipated, a significant difference was observed between men and women on the posttest measure. Men performed consistently better than women, especially when application of the number base principles was required. This finding added empirical support to previous research evidence (e.g., Billings, 1934; Guetzkow, 1951; Sweeney, 1953) which indicated that men perform better than women in problem solving activities.

The significant sex by intelligence interaction is, however, interpreted to be internally invalid because two women *S*s in the first quartile could not complete the learning task to criterion. Their randomly selected replacements appeared to be more highly motivated because they completed the learning task to criterion. Consequently, it seems reasonable to explain the observed effect as an artifact of internal invalidity due to motivational bias brought about by experimental mortality.

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FOOTNOTES

[1]The research reported herein was performed pursuant to a grant from the U. S. Office of Education, Department of Health, Education, and Welfare. An elaboration of the rationale, procedure, and findings can be found in the final report (Grotelueschen, 1967).

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[2]The term *structure* refers to the content and organization of the learning material, and *sequence* refers to the manner in which the learning material is arranged and ordered.

[3]The history of measurement program was adapted from a published program (TMI-Grolier, 1962). Permission to adapt this program was given by Teaching Machines, Inc.

Table 1

Means and Standard Deviations of Sample Characteristics

by Sex and Intelligence Level

Intelligence Quartile		Pretest		WAIS Full Scaled Score		Age		Years of Education	
		Men	Women	Men	Women	Men	Women	Men	Women
First	*M*	2.67	2.00	110.92	110.33	41.08	39.83	13.25	12.58
	SD	1.31	1.22	4.41	5.48	8.66	10.38	2.38	1.19
Second	*M*	3.08	3.00	126.67	126.67	37.00	37.92	14.33	13.92
	SD	1.32	1.15	4.13	3.90	8.58	9.38	1.80	1.93
Third	*M*	3.25	3.33	140.83	140.33	38.75	36.75	14.50	13.08
	SD	1.23	1.55	3.02	3.25	9.35	8.82	2.14	1.61
Fourth	*M*	3.00	3.42	152.08	152.42	37.67	41.42	14.25	14.25
	SD	1.53	1.32	3.59	5.12	7.26	8.79	2.05	1.92
Total	*M*	3.00	2.94	132.63	132.44	38.63	38.98	14.08	13.46
	SD	1.37	1.43	15.90	16.32	8.64	9.53	2.16	1.81

Table 2

Number of Frames, Responses, Mean Errors, and Mean Learning Time by Introductory Treatment

Program	No. of Frames	No. of Responses	Mean No. of Errors	Mean Time in Minutes
History	94	126	6.42	33.62
Base Ten	94	116	5.21	37.33
Base Seven	95	111	9.38	43.42
Principles	96	121	13.00	56.83

Table 3

Analysis of Variance of Criterion Measures

		Posttest		Trials		Errors	
Source	*df*	*MS*	*F*	*MS*	*F*	*MS*	*F*
Introductory Material (A)	3	4.36	<1.00	115.37	2.08	3305.69	1.86
Learning Task (B)	2	.22	<1.00	1239.78	22.31**	29203.00	16.40**
Intelligence (C)	3	35.42	6.56**	735.29	13.23**	19775.25	11.10**
Sex (D)	1	54.00	10.00**	126.04	2.27	3775.04	2.12
A X B	6	4.41	<1.00	72.62	1.31	2052.62	1.15
A X C	9	7.48	1.38	94.22	1.70	2408.56	1.35
A X D	3	2.03	<1.00	24.15	<1.00	809.01	<1.00
B X C	6	4.30	<1.00	55.62	<1.00	1021.60	<1.00
B X D	2	2.84	<1.00	13.26	<1.00	755.01	<1.00
C X D	3	26.92	4.98**	94.07	1.69	3598.07	2.02
Error	57	5.40	--	55.57	--	1780.99	--

**$p < .01$

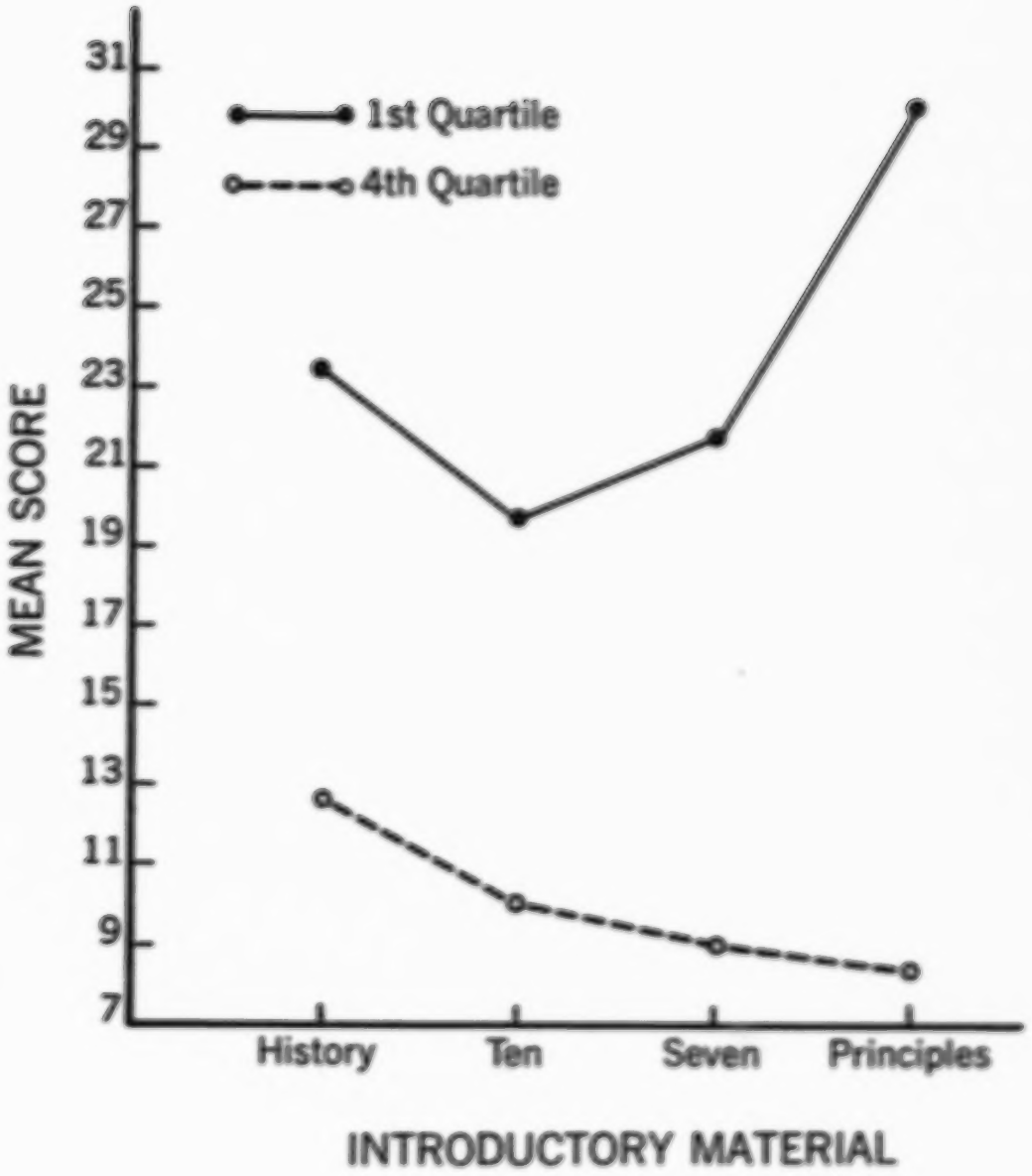

Fig. 1. Trials means for levels of intelligence at each introductory material level.

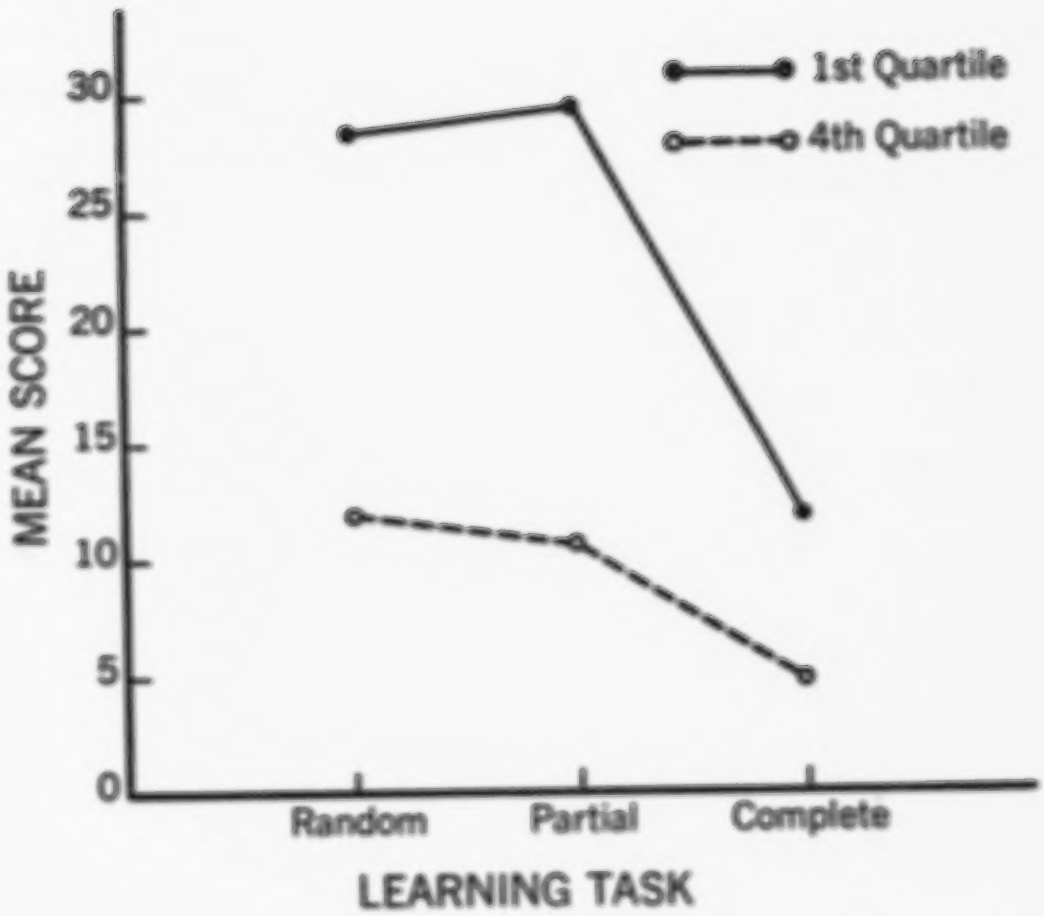

Fig. 2. Trials means for levels of intelligence at each learning task level.

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